Appendix D: Quasi-Experimental Footfall Analysis

This is a detailed technical note setting out the use of a quasi-experimental analysis of footfall data collected by Historic England in order to support the evaluation of the HSHAZ programme. As explained in this note, the usefulness of the data and the approach provides indicative intelligence regarding impact.

Glossary

ATT	Average Treatment effect on the Treated
BSD	Business Structural Database
DID	Difference-in-differences
GSC	Generalised Synthetic Control
HSHAZ	High Street Heritage Action Zones, a program led by Historic England aimed at revitalizing high streets across England
IFE	Interactive fixed effects model
MSPE	Mean Square Prediction Error
NRMSE	Normalised Root Mean Square Error
QE approaches	Quasi Experimental approaches
RMSE	Root Mean Square Error
SCM Profile	Synthetic Control Model Profile
VOA	Valuation Office Agency

Introduction

Quasi-Experimental (QE) analysis of area-based interventions has frequently presented difficulty. In the case of the HSHAZ programme and its schemes, there exist specific challenges related to spatial scale and hyper-local geographies. There are next to no datasets that permit scrutiny of area performance metrics at hyper-local level and there is an absence of appropriate covariate datasets.

Historic England has taken the initiative in acquiring third-party footfall data for a sample of HSHAZ areas/comparators which can be scaled down to polygons broadly matching HSHAZ and surrounding buffer areas. This appendix reports an analysis of potential High Street Heritage Action Zones (HSHAZ) impact using this footfall data. In terms of process:

- the data supplier (HuQ) has attempted to 'cleanse' the footfall datasets to remove the effects of fixed specific attractors such as supermarkets and transport hubs but we must accept that the supplied data may retain some degree of noise.
- choice of comparators is constrained by a previous analysis via what is described as an 'analogue' process rather than any formal statistical matching procedure;
- there is uncertainty regarding the point at which potential impact should be assessed. While we can be certain of formal scheme completion dates, any such impacts may reflect the timing of visual amenity improvements rather than financial or administrative timescales;
- the absence of covariate datasets raises the spectre of omitted variable bias (OVB). We must accept that this remains a risk in attempting to isolate any impact of HAZ activity but it also directs attention towards the nature of the identification strategy employed.

We have used a generalised synthetic control methodology which seeks to moderate the influence of both time-invariant and time-varying confounders through an interactive fixed effects (IFE) model whereby unit specific intercepts interact with time-varying coefficients. This goes some way to addressing OVB risk, but the scale of moderation is unknown and there remains a risk of related bias in estimated parameters. Likewise, a different profile of comparators may produce differing results with varying impact attribution.

Ultimately, the approach is experimental in nature. The view of the evaluation team is that the exercise is, subject to the above caveats and constraints, of value in examining the HSHAZ programme. It cannot be definitive, and general validity is limited through the nature of the number of HSHAZ schemes selected for analysis, but it provides something of a potential base for future evaluations of this nature.

This appendix reviews the nature of the data challenge facing the evaluation of HSHAZ, outlines the footfall data accessed for a sample of HSHAZ scheme areas and proceeds to undertake a synthetic control analysis of each individual area along with a combined area analysis.

The Data Challenge

HSHAZ intervention is intended to 'transform and restore disused and dilapidated buildings into new homes, shops, workplaces and community spaces, restoring local historic character and improving public realm'. Together, these ambitions imply the impacts associated with increasing activity and vitality of HSHAZ zones are likely to be:

- directly evidenced through physical metrics such as occupancy and vacancy, and business/commercial metrics such as employment, turnover; and

- indirectly evidenced through other metrics such as visitors, footfall, spend and land/property values.

Alongside the specification of metrics, however, a quasi-experimental (QE) assessment requires that metrics be available both prior to and post intervention, reference both HSHAZ and any comparator(s) and reflect the hyper-local HSHAZ spatial context.

Direct Evidence: Physical, Business and Commercial Metrics

Intervention is presumed to enhance the vitality of HSHAZ scheme areas, returning unused premises to viable operation, improving public realm, attracting new occupants and/or reducing numbers of vacant units. Unfortunately, occupancy/vacancy data is not readily available at low level geography and what is available typically lacks any robust longitudinal comparator profile.

Improved vitality may also be reflected in increases in employment and turnover within/through existing/new businesses in zones. The primary source of individual UK business level employment and turnover is the Business Structure Database (BSD). Recent changes to the structure of the BSD have weakened capacity to focus on hyper-local geographies. In addition, there is the challenge related to lags in the supply of content. With much HSHAZ activity completing in 2024, a robust, relevant dataset may not be available until 2025/26.

Indirect Evidence: Visitor/Footfall/Spend/Land & Property Value Metrics

In circumstances where direct evidence is difficult to observe or obtain, it may be feasible to infer performance/impact through proxy or indirect metrics. Improved post-intervention vitality of HSHAZ zones is likely to correlate with 'activity' patterns, evidenced through visitor or footfall metrics. Similarly, improvements to the HSHAZ built environment may serve to enhance the attractiveness of land/property in close proximity such that values increase.

Data on land and commercial property values are typically limited to broad geographies or major urban areas, which constrains application to the HSHAZ environment. While the Valuation Office Agency (VOA) publishes ratings lists, these are updated on an irregular basis which severely limits scope for longitudinal analysis.

Harnessing a range of technologies, there has been significant growth in both the number of providers and volume of footfall profiles over recent years with improvements facilitating coverage at hyper-local geographies. In practice, footfall is one of the few metrics that can be scaled to differential geographies making it an innovative and 'exciting' candidate for evaluation purposes.

To assist the evaluation process, Heritage England commissioned HuQ to provide historic and live daily footfall data for 10 candidate HSHAZ zone polygons[1] and 20 comparator areas[2], along with surrounding 'buffer' areas for each, between January 2019 and August 2024. This dataset provides the basis of the analysis that follows.

Footfall Profiles

Heritage England commissioned HuQ to provide historic and live daily footfall data for each HSHAZ polygon and a surrounding 'buffer' between January 2019 and August 2024 Buffers were set at either 100m or 200m using the ratio of commercial to residential units as a discriminator. Residents were excluded from footfall counts and adjustments made to limit multiple same-device recognition. HuQ sought to remove a range of footfall drivers such as the presence of nearby transport

[1] Gloucester, Harlesden, Leeds, Leominster, Middlesbrough, Poole, Ryde, Swaffham, Tyldesley, Wakefield.

[2] Bradford, Bromley, Brixham, Bury, Cromer, Downham Market, Fareham, Hereford, Launcesteon, Little Lever, Liskeard, Manchester, Newcastle upon Tyne, North End Road, Ryde, Rye, Sunderland, Westhoughton, Willesden Green, Windsor

hubs/supermarkets and also provided similar data for a set of comparators based on a comparator analysis undertaken by Geolytix for Historic England using an 'analogue proximity' approach.

The data supplied is in the form of a polygon count corresponding to each HSHAZ zone/comparator and a combined polygon/buffer count.

A series of figures accompany this document but are not included because of accessibility criteria. These are available on request.

The data details daily HSHAZ and HSHAZ /Buffer footfall between January 2019 and August 2024 and supplied by HuQ:

- despite differences in volume across areas, all clearly display the drop in footfall at the onset of the first national COVID lockdown in March/April 2020;
- most typically display something of a cyclical pattern in following months with emerging recovery offset by additional lockdown periods;
- there is evidence of a surge in activity in late 2021 through to the autumn of 2022 which drops away in the aftermath of the Russia/Ukraine conflict and associated energy price implications;
- footfall climbs again in spring/summer 2023 before tailing away once more in the autumn and winter; and
- unlike previous years, there is less evidence of a seasonal increase in activity in spring/summer 2024.

The data makes comparison of HSHAZ and combined HSHAZ /buffer area patterns more straightforward and displays some differences between HSHAZ areas:

- there are a group of HSHAZ areas (Harlesden, Leominster, Swaffham, Ryde, Tyldesley) where footfall patterns in core polygons follow the combined core/buffer profile closely with relatively minimal 'distance' between the two;
- another group (Gloucester, Poole, Wakefield) display broadly similar patterns but with emerging distance over time;
- a final group (Leeds, Middlesbrough) where HSHAZ footfall remains rather flat against the combined core/buffer profile

For purposes of analysis we generate a ratio of HSHAZ zone visits to combined HSHAZ zone/buffer areas visits – a pseudo penetration rate that lies between 0 and 1 with any evidence of increasing values, post investment and relative to comparators, potentially indicating a positive impact of intervention.

The data details the ratio of HSHAZ to HSHAZ/buffer footfall. As the former are nominally included in the latter, all ratio values should have a unit maximum value though Ryde, Swaffham and Tydesley all have isolated ratio values above one:

- most HSHAZ areas display a u-shaped pattern with the proportion of footfall traffic in the buffer area also appearing in the HSHAZ area declining into the first national lockdown and its aftermath before recovering from mid 2021;
- the vast majority of HSHAZ areas recover 'penetration' levels prior to Covid by the end of the period but this is not the case for Leeds and Middlesbrough:
  - the Leeds penetration profile, while cyclical, trends downwards across the entire period to levels broadly 50% of the pre-covid rate;
  - Middlesbrough penetration does recover from COVID but to levels some way short of the pre-covid period;

As noted earlier, penetration rates in a number of areas drop away in the spring and summer of 2024.

Methodology

The primary challenge in all ex-post QE policy evaluations is causal identification. In most instances, QE approaches rely on the creation of a comparative framework through which to generate a counterfactual outcome and used, post-intervention, to estimate net impact. This framework requires that comparisons be made on a as 'like-for-like' basis as possible.

The application of QE has been dominated by Difference-in-Differences (DID) designs with a critical identifying feature of 'parallel trends'. Here, average outcomes of treated and control units that follow parallel paths in the absence of intervention is required to provide the basis of post-intervention validation. In practice, robust parallel pre-treatment trends are rarely evident, introducing uncertainty into subsequent impact estimates.

Pre-treatment variability is often the result of unobserved, time-varying confounders which are far more difficult to accommodate than time-invariant equivalents. One way of addressing the issue has been to 'condition' on pre-treatment observables using matching methods, balancing the influence of confounders across treatment and control groups. A variation of this design lies in the emergence of synthetic approaches which match pre-treatment outcomes across sets of treated and comparator control units in pre-intervention periods, with match quality operating as the basis for post-treatment validation.

An alternative approach is to model unobserved time-varying heterogeneity. One option is to add unit-specific linear/quadratic time trends to conventional two-way fixed effects models. Another option is to model unobserved time-varying confounders semi-parametrically through interactive fixed effects (IFE) models whereby unit specific intercepts interact with time-varying coefficients.

The time-varying coefficients are often referred to as (latent) factors while the unit-specific intercepts are labeled as factor loadings. Such models are estimated by (iteratively) conducting a factor analysis of the residuals from a linear model and subsequently estimating the linear model that incorporates the most influential factors.

The approach adopted for the HSHAZ exercise employs an IFE model and is adapted from the Generalised Synthetic Control (GSC) approach outlined by Xu (2017).[3] In the first instance the approach estimates an IFE model using only control group data and identifies a (fixed) number of latent factors with factor loadings assigned to the treated unit by (linearly) projecting pre-treatment treated outcomes onto the space defined by these factors. Secondly, it imputes treated counterfactuals reflecting the estimated factors and factor loadings.

If Y_{it} is the outcome of interest of unit i at time t, Xu outlines a functional form:

$$Y_{it} = \delta_{it}D_{it} + \beta x_{it} + \lambda_i f_t + \varepsilon_{it}$$

where the treatment indicator D_{it} equals 1 if unit i has been exposed to the treatment post time t and equals 0 otherwise. δ_{it} is the heterogeneous treatment effect on unit i at time t; x_{it} is a vector of observed covariates, β is a vector of unknown parameters; f_t is an vector of unobserved common factors, λ_i is a vector of unknown factor loadings, and ε_{it} accounts for unobserved shocks to unit i at time t. It is assumed that treated and control units are affected by the same set of factors and the number of factors is fixed during the observed time period.

The factor component of the model is assumed to take a linear, additive form with factors normalised and orthogonal. Xu points out that this covers a wide range of unobserved heterogeneities with conventional additive unit and time fixed effects as special cases. In addition the approach covers cases ranging from unit-specific linear or quadratic time trends to autoregressive components. In practice, as long as an unobserved random variable can be decomposed into a multiplicative form it can typically be absorbed through this approach. It cannot, however, capture unobserved confounders that are independent across units.

A strict exogeneity condition is imposed whereby the error term of any unit, at any time period, is independent of (i) treatment assignment (ii) any observed covariates and (iii) unobserved cross-sectional/temporal heterogeneities of all units at all periods. Likewise, there must only exist weak serial dependence of error terms alongside a set of regularity conditions to ensure convergence of estimators.

[3] Xu, Y. (2017), Generalized Synthetic Control Method: Causal Inference with Interactive Fixed Effects Models, Political Analysis (2017) vol. 25:57–76

To determine the numbers of factors to be used in the GSC approach, Xu introduces a leave-one-out-cross-validation (LOOCV) procedure. This retains a small amount of data and uses the rest of data to predict the retained information. The algorithm then chooses the model that (on average) makes the most accurate predictions using Mean Square Prediction Error (MSPE). The number of factors is limited to a maximum of five to achieve a balance between the risks of underfitting and overfitting.

Finally, a parametric bootstrap procedure is used to obtain the uncertainty estimates of the GSC estimator, resampling the residual time-series to preserve serial correlation within the units and limiting underestimation of standard errors.

The model employed in the exercise is direct replicate of that outlined above:

$P_{it} = \delta_{it}D_{it} + \beta x_{it} + \lambda_i f_t + \varepsilon_{it}$

where P_{it} is the foottfall penetration rate in HSHAZ area i at time t and all other parameters are as defined - the treatment indicator D_{it} equals 1 over the period defined as the treatment period in any given HSHAZ area i and 0 otherwise.

The hyper-local nature of the HSHAZ schemes modeling places some constraints on the application of the GSC approach. The most notable of these is the absence of any appropriate covariate dataset – we have no formal set of controls at hyper-local level - though there remains some debate in synthetic control research as to whether the approach is/is not enhanced by the addition of covariates[4].

In addition, the point at which impact should be assessed is somewhat unclear. Formal completion of HSHAZ for most of the sample sites was end March 2024[5] and while financial records enable analysis of the spend profile for nearly all HSHAZ schemes, it is conceivable that impact effects (if any) may have emerged prior to formal completion, especially in the case of investments relating to visual amenity. For this reason we test a series of models that work backwards in time (by quarter) from the nominal completion date. We are also able to test a combined model where all sample HSHAZ areas are assessed simultaneously and a variant which reduces the overall sample to town centres.

In terms of the periods defined in the results tables, April 2024 models have 63 pre-periods and 5 post-periods (starting January 2019). Observations then adjust in quarter sequences – January 2024 has 60 pre-period observations and 8 post-period observation with the earliest period (January 2023) having 51 pre-period observations and 17 post-period observations.

Finally, rather than running GSC models in which each sample HSHAZ scheme is paired with its (two) designated comparators alone, we use all available comparators maximizing the control dataset and allowing greater bandwidth for weight structures. With one comparator assigned to two different HSHAZ areas, most models contain one treatment unit and 19 control units.

We present results for all of the sample areas in terms of a number of features, namely the:

- nominal spend profile: -
  - the percentage of total spend in each HSHAZ at each assessment period;
- number of factors employed in each model along with the associated MSPE relative to the zero factor MSPE:
  - the reduction between the (zero factor) base MSPE and applied MSPE provides an indication of the improvement in modeling performance through the use of factors;

[4] We report on the inclusion of a weather data series later in the report.

[5] In modelling we refer to breakpoints in terms of the start of the assessment period. As such, end quarter March 2024 is referred to as April 2024 and so on.

- root mean square error (RMSE) of unit/control pre/post time-points and their ratio:
  - RMSE measures the average distance/gap between observed and SCM predicted penetration (treatment/control ratio) rates. Lower values indicate closer fit;
  - comparison of pre and post period RMSEs in any single model period provides an indirect indicator (and alternative validation) of whether intervention may have impacted in that period – one would normally expect a higher post/pre period RMSE ratio to be present when ATET coefficients are significant and vice-versa;
- normalised (max/min) root mean square error (NRMSE) to facilitate RMSE comparisons across areas:
  - NRSME is a way of comparing model performance across areas on a common basis in the presence of differences in scale;
  - NRSME (pre) facilitates assessment of model performance prior to intervention across all models;
- ATT (Average Treatment effect on the Treated) coefficients:
  - ATT (or ATET) is a standard measure of impact and is the primary basis on which impact is assessed in the models.

Gloucester HSHAZ

The Gloucester HSHAZ spend profile shows a total of some £3m over the programme period with 88% of the total achieved by April 2023 rising to 92% by July 2023, 94% by January 2024 and 100% by April 2024. Table C1 reports the results of the broader GSC process across five quarters from April 2024.

All models identify five latent factors with a reported mean squared prediction error (MSPE) reduction of between 50% and 70% from the base with zero factors. RMSE (Root Mean Square Error) for the pre-timeframe across models is the second lowest of all candidate HSHAZ areas in the analysis with similarly low NRSMSE values across areas and timeframes.

RMSE is lowest for the longest pre-period (April 2024) but increases by only a very modest amount moving back in time suggesting that models are relatively consistent in matching the treated (Gloucester) ratio profile. This is confirmed with scrutiny of the data which indicates a relatively high degree of correspondence between treated and control ratios in all models. The RMSE ratio profiles suggest an increasing treatment/control unit differential in the most recent models and shortening the matching pre-period has a small but evident impact in terms of the post-period counterfactual with a less deep curve.

These features are reflected in the estimated ATT coefficient (Average Treatment effect on the Treated) which is significant for the April 2024 model and weakly significant for the January 2024 model but insignificant for all other periods.[6]

Table C1: Gloucester HSHAZ GSC Profile

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	100%	94%	92%	92%	88%
ATT Coefficient	0.100** (0.051)	0.069* (0.041)	0.048 (0.036)	0.018 (0.040)	0.019 (0.033)
RMSE (Pre)	0.0228	0.0235	0.0238	0.0239	0.0245
RMSE (Post)	0.1194	0.0924	0.0798	0.0680	0.0627
RMSE Ratio	5.225	3.933	3.343	2.845	2.554
NRMSE (pre)	0.063	0.065	0.066	0.066	0.068
No. of Factors	5	5	5	5	5
Base MSPE	0.00471	0.00481	0.00499	0.00524	0.00489
Applied MSPE	0.00150	0.00157	0.00261	0.00162	0.00178
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Harlesden HSHAZ

Harlesden is different from others in the sample, completing by October 2022 and in this case we model two quarters either side of this date. The Harlesden spend profile shows a total of some £0.75m

[6] Significance in all Tables is defined as: *** (1%), ** (5%), * (10%)

over the programme period with 71% of the total achieved by April 2022 rising to 86% by July 2022and 100% by October 2022.

Table C2 reports the results of the GSC process across the five quarters with data displaying pre/post timeframes alongside the Harlesden ratio and model counterfactual for each quarter.

All models identify five latent factors with a reported MSPE reduction of between 11% and 50% from the base with zero factors and it is evident that reductions are generally larger for the three most recent periods.

RMSE for the pre-timeframe across models is relatively high and the same is true of the NRMSE profile. Analysis of the data suggests that correspondence between the Harlesden and synthetic penetration ratios is less precise than other target areas.

RMSE for the post period is more variable with the ratio between periods higher for the October 2022 and January 23 periods and smaller elsewhere. Shortening the matching pre-period does have a visible impact in terms of a visible drift upwards in the synthetic control.

The RMSE ratio and the synthetic control profiles are consistent with the pattern of ATT coefficients – models indicate significant ATT coefficients at the immediate completion of the programme (October 2022 and January 2023) with significance levels falling away by April 2023.

Table C2: Harlesden HSHAZ SCM Profile

	April 2023	January 2023	October 2022	July 2022	April 2022
Spend %	100%	100%	100%	86%	71%
ATT Coefficient	0.066* (0.035)	0.077** (0.037)	0.077** (0.032)	0.006 (0.015)	-0.019* (0.011)
RMSE (Pre)	0.0477	0.0510	0.0501	0.0423	0.0481
RMSE (Post)	0.0351	0.0746	0.0867	0.0445	0.0044
RMSE Ratio	0.734	1.461	1.731	1.051	0.922
NRMSE (Pre)	0.152	0.163	0.160	0.135	0.154
No. of Factors	5	5	5	5	5
Base MSPE	0.00270	0.00261	0.00264	0.00193	0.00176
Applied MSPE	0.00166	0.00129	0.00128	0.00172	0.00125
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Leeds HSHAZ

The Leeds spend profile shows a total of some £2m over the programme period with 71% of spend achieved by April 2023 rising to 87% by July 2022 and 99% by October 2023. Previous sections have illustrated that the penetration ratio for Leeds HSHAZ exhibits a cyclical but downward trend across the entire sample period.

Table C3 reports the results of the GSC process across the five quarters.

Four of the five models indicate 3 factor models with one indicating a 5 factor structure. Reported MSPE profiles show reductions of between 40% and 75% from the base with zero factors and reductions increasing for more recent periods.

Despite strong cyclicality, RMSE for the pre-timeframe across models is relatively low. Consideration of the data also suggests correspondence between the Leeds and synthetic penetration ratios is reasonably high. NRMSE values are, however, relatively high indicating greater variability once the range of ratio values is taken into account.

RMSE for the post period is more variable with the ratio between periods lowest in the most recent (April 2024) period and higher across all other periods. Shortening the matching pre-period does have a visible impact on correspondence with a visible drift upwards in the synthetic control.

All ATT coefficients are negative in sign and none are significant, providing no indication of any policy impact.

Table C3: Leeds HSHAZ SCM Profile

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	100%	100%	99%	87%	83%
ATT Coefficient	-0.034 (0.066)	-0.027 (0.036)	-0.048 (0.039)	-0.049 (0.051)	-0.059 (0.045)
RMSE (Pre)	0.0246	0.0219	0.0234	0.0242	0.0229
RMSE (Post)	0.0358	0.0641	0.0548	0.0562	0.0647
RMSE Ratio	1.453	2.92	2.343	2.316	2.821
NRMSE (Pre)	0.111	0.099	0.123	0.146	0.139
No. of Factors	3	5	3	3	3
Base MSPE	0.00467	0.00433	0.00342	0.00259	0.00208
Applied MSPE	0.00113	0.00109	0.00097	0.00102	0.00090
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Leominster HSHAZ

The spend profile for Leominster was not available at the time of analysis. Table C4 reports the results of the GSC process across the five quarters.

All models identify three latent factors with MSPE reductions of between 35% and 45% from the base with zero factors and it is evident that MSPE reductions increase as models progress from longer to shorter (more recent) periods.

RMSE for the pre-timeframe is broadly similar across periods ranging from 0.0424 to 0.0463 with lowest values in the more recent periods. The data shows noticeable gapping and while NRMSE values are on the high side, they are far from the highest across areas.

RMSE for the post period increases marginally from shorter to more distant time periods with the RMSE ratio also increasing in the same way. Shortening the matching pre-period shows a visible drift downwards in the synthetic control.

Overall, these features suggest a positive but moderating treatment/control unit differential in the early periods which falls away in more recent models. This is confirmed in the pattern of ATT coefficients. Models indicate highly significant ATT coefficients in April/July 2023 with moderate to low significance in October 2023 and no significance thereafter. Other scheme sources suggest that the bulk of construction work was completed by June 2023 which sits reasonably well with the ATT profile.

Table C7: Leominster HSHAZ **SCM Profile**

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	n/a	n/a	n/a	n/a	n/a
ATT Coefficient	0.044 (0.073)	0.058 (0.048)	0.079* (0.044)	0.112** (0.054)	0.111** (0.054)
RMSE (Pre)	0.0424	0.0435	0.0446	0.0456	0.0463
RMSE (Post)	0.0475	0.0649	0.0828	0.1146	0.1178
RMSE Ratio	1.118	1.490	1.857	2.508	2.543
NRMSE (Pre)	0.101	0.109	0.112	0.115	0.116
No. of Factors	3	3	3	3	3
Base MSPE	0.00848	0.00767	0.00737	0.00728	0.00730
Applied MSPE	0.00460	0.00454	0.00454	0.00453	0.00469
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Middlesbrough HSHAZ

The Middlesbrough spend profile shows a total of some £2.2m over the programme period and is more weighted towards recent quarters than other HSHAZ areas, with 63% of spend achieved by April 2023, 69% and 78% by July/October 2023 and 100% by April 2024.

Table C5 reports the results of the GSC process across the five quarters.

Models identify a mix of 3 to 5 latent factors with reported MSPE reductions of between 45% and 69% from the base with zero factors and more pronounced reductions in the earlier periods which decline as models progress to more recent times.

RMSE for the pre-timeframe ranges from 0.0231 to 0.0366 with lowest values in the earlier periods and values consistently rising in progression to more recent timeframes. While there is some evidence of gapping in the data, NRMSE values are generally lower than other areas indicating better than average correspondence in the pre-period.

RMSE for the post period generally increases towards earlier periods with the RMSE ratio similarly rising. The combined RMSE profiles suggest a positive treatment/control unit differential in the early periods which reduces in more recent models. This is also reflected in the data where shortening the matching pre-period produces a visible drift downwards in the synthetic control.

In line with both the RMSE, models indicate significant ATT coefficients across all periods with the exception of April 2024.

Table C5: Middlesbrough HSHAZ **SCM Profile**

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	100%	83%	78%	69%	63%
ATT Coefficient	0.118 (0.081)	0.113** (0.053)	0.094** (0.039)	0.136** (0.065)	0.146*** (0.052)
RMSE (Pre)	0.0366	0.0340	0.0312	0.0284	0.0231
RMSE (Post)	0.1222	0.1304	0.1104	0.1539	0.1749
RMSE Ratio	3.335	3.833	3.533	5.416	7.574
NRMSE (Pre)	0.084	0.078	0.071	0.065	0.053
No. of Factors	3	3	5	3	4
Base MSPE	0.00659	0.00680	0.00714	0.00752	0.00796
Applied MSPE	0.00361	0.00320	0.00335	0.00310	0.00250
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Poole HSHAZ

The Poole spend profile shows a total of some £3.5m over the programme period and is very heavily weighted towards recent quarters, with only 34% of spend achieved by April 2023, 35% by October 2023, 73% at January 2024 and 100% by April 2024.

Table C6 reports the results of the GSC process.

Models identify a mix of two to five latent factors with one model citing no factors, a much more variable pattern than in other areas. Likewise, there are very limited MSPE reductions in any of the models suggesting that the IFE structure struggles to operate effectively.

RMSE for the pre-timeframe ranges from 0.0266 to 0.0352 with lowest values in the earlier periods. NRMSE values are higher than average across areas with gapping between the penetration and control ratios also evident in the data.

RMSE for the post period lies in a narrow, relatively flat band with the RMSE ratio showing less variability than in other areas. Variability in the latter is, however, also reflected in the data where shortening the matching pre-period results in both higher/lower synthetic control profiles.

RMSE for the post period indicates a small unit differential in all models and none of the ATT coefficients are significant. Given the pattern of spend, it is conceivable that very recent completion (with 25% of total spend in the last quarter) is too premature to be reflected in the footfall data.

Table C6: Poole HSHAZ SCM Profile					
	April 2024	**January 2024**	**October 2023**	**July 2023**	**April 2023**
Spend %	100%	73%	35%	34%	34%
ATT Coefficient	0.076 (0.058)	0.082 (0.055)	0.024 (0.053)	0.031 (0.029)	0.031 (0.029)
RMSE (Pre)	0.0350	0.0352	0.0309	0.0266	0.0266
RMSE (Post)	0.0774	0.0873	0.0615	0.0750	0.0750
RMSE Ratio	2.210	2.479	1.989	2.819	2.819
NRMSE (Pre)	0.134	0.135	0.122	0.118	0.141
No. of Factors	2	0	2	5	5
Base MSPE	0.00154	0.00142	0.00134	0.00114	0.00114
Applied MSPE	0.00153	0.00142	0.00129	0.00103	0.00103
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Ryde HSHAZ

The Ryde profile shows a total of some £0.75m over the programme period with 71% achieved by April 2023, a modest increase to 77% by January 2024 and jumping to 100% by April 2024.

Models identify a mix of one to three latent factors. MSPE reductions are broadly similar across models ranging from 65% to 70% (Table C10). RMSE for the pre-timeframe ranges from 0.0234 to 0.0426 with no particular pattern across models/periods other than a clear increase in the most recent period. Pre-period NRMSE is notably lower than average and among the lowest across models.

RMSEs for the post period are notably higher implying a unit differential in most models. Although variable, inspection of the data indicates that shortening the matching pre-period has a notable impact in synthetic control profiles.

In most (but not all) instances, the latter drifts downwards and leads to more significant ATT coefficients. The ATT profile implies highly significant differences in the penetration rate for early periods, weaker significance for the middle periods and insignificance for the April 2023 model.

With regard to the pattern of spend, elsewhere it may be that very recent completion (with 23% of total spend in the last quarter) is too premature to be reflected in the footfall data or that any visual amenity benefit was evident prior to formal completion.

Table C7: Ryde HSHAZ SCM Profile					
	April 2024	**January 2024**	**October 2023**	**July 2023**	**April 2023**
Spend %	100%	77%	75%	73%	71%

ATT Coefficient	0.085 (0.094)	0.093* (0.055)	0.116* (0.066)	0.168*** (0.051)	0.151*** (0.048)
RMSE (Pre)	0.0426	0.0234	0.0369	0.0342	0.0349
RMSE (Post)	0.1053	0.2193	0.1462	0.1872	0.1784
RMSE Ratio	2.469	9.336	3.952	5.474	5.112
NRMSE (Pre)	0.064	0.035	0.066	0.061	0.062
No. of Factors	1	1	1	3	3
Base MSPE	0.01563	0.01504	0.01105	0.00967	0.00965
Applied MSPE	0.00551	0.00515	0.00328	0.00315	0.00332
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Swaffham HSHAZ

The Swaffham profile shows a relatively small total of some £0.58m over the programme period with 31% achieved by April 2023, a 57% by October 2023, 72% by January 2024 and 100% by April 2024. In essence, two thirds of spend occurred between October 2023 and April 2024.

Models identify a mix of one to two latent factors with one model citing no factors with negligible MSPE reductions in any of the models suggesting that the IFE structure struggles to operate effectively.

RMSE for the pre-timeframe ranges from 0.0403 to 0.0475 with no particular patterns across models/periods. Overall pre-period NRMSE is among the highest in the candidate set withdata showing significant gapping across the pre-period. The GSC models clearly do not provide a competent synthetic control.

RMSEs for the post period are relatively close to the pre-period. Shortening the pre-period has minimal effects in the synthetic control, other than in the two earliest periods where there is some evidence of downward drift.

In practice, none of the ATT coefficients are significant. Whether this is related to the profile of spend towards the most recent period is unclear.

Table C8: Swaffham HSHAZ SCM Profile

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	100%	72%	57%	36%	31%
ATT Coefficient	0.058 (0.070)	0.043 (0.054)	0.029 (0.049)	0.013 (0.056)	0.078 (0.054)
RMSE (Pre)	0.0441	0.0448	0.0460	0.0475	0.0403
RMSE (Post)	0.0632	0.0529	0.0450	0.0453	0.0871
RMSE Ratio	1.433	1.179	0.979	0.954	2.161
NRMSE (Pre)	0.154	0.157	0.161	0.166	0.141

No. of Factors	1	1	1	0	2
Base MSPE	0.00233	0.00242	0.00254	0.00260	0.00254
Applied MSPE	0.00231	0.00240	0.00253	0.00260	0.00246
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Tyldesley HSHAZ

The Tyldesley profile shows a total of some £1.5m over the programme period with 63% achieved by April 2023, 66% by October 2023, 86% by January 2024 and 100% by April 2024.

Models mostly identify five latent factors with MSPE reductions in the range of 40% to 60% (Table C9). RMSE for the pre-period timeframe ranges from 0.0244 to 0.036 with values increasing from April 2023 to more recent periods.

In this case, shortening the pre-period results in higher RMSE values and is displayed in the data where pre-period correspondence between the actual and synthetic control penetration ratios improves moving back in time. More generally, pre-period NRMSEs are significantly lower than many other areas indicating relatively good correspondence between unit and control ratios.

RMSE for the post period are notably higher implying a unit differential in most models. Inspection of the data indicates that shortening the matching pre-period typically results in an upward drift of the synthetic control.

Despite the latter feature, ATT coefficients are strongly significant across all models, though variable in scale. [7]

Table C9: Tyldesley HSHAZ SCM Profile

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	100%	86%	66%	64%	63%
ATT Coefficient	0.155** (0.069)	0.076** (0.036)	0.080** (0.035)	0.097** (0.038)	0.094** (0.037)
RMSE (Pre)	0.0360	0.0323	0.0302	0.0291	0.0244
RMSE (Post)	0.1578	0.1086	0.1086	0.1182	0.1185
RMSE Ratio	4.380	3.361	3.589	4.062	4.854
NRMSE	0.070	0.062	0.058	0.056	0.047
No. of Factors	4	5	5	5	5
Base MSPE	0.00553	0.00555	0.00567	0.00585	0.00618
Applied MSPE	0.00326	0.00295	0.00275	0.00267	0.00251

[7] The high April 2024 coefficient may partly reflect the unexpectedly high (i.e. >1) ratio identified at the start of this analysis.

Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

Wakefield HSHAZ

The Wakefield spend profile was not available at the time of analysis.

Models mostly identify a mix (0,3,5) of latent factors, which, as elsewhere, tends to suggest the IFE approach is struggling to find consistency across models/periods. MSPE reductions are negligible for the three most recent periods and around 20% for later periods, lower than many other areas.

RMSEs for the pre-period timeframe range from 0.025 to 0.041 with more recent period values higher than earlier periods. Shortening the pre-period results in lower RMSE values and is displayed in the data where pre-period correspondence between the actual and synthetic control penetration ratios improves moving back in time. NRMSE values are notably higher than average and thereby many other areas for the more recent periods with broadly average values for earlier periods.

RMSEs for the post period are generally (apart from April 2024) higher, implying a unit differential in later period models. Inspection of the data indicates that shortening the matching pre-period tends to introduce an upward spike in the synthetic control, increasing the unit differential and resulting in mostly negative (though insignificant) ATT coefficients. Other scheme sources suggest that the bulk of construction was completed by October 2023 which coincides with the one weakly significant ATT coefficient.

Table C10: Wakefield HSHAZ SCM Profile

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	n/a	n/a	n/a	n/a	n/a
ATT Coefficient	0.000 (0.059)	-0.051 (0.055)	-0.061* (0.035)	-0.037 (0.038)	-0.039 (0.036)
RMSE (Pre)	0.0412	0.0449	0.0259	0.0269	0.0253
RMSE (Post)	0.0288	0.0588	0.1239	0.1043	0.1067
RMSE Ratio	0.700	1.306	4.777	3.871	4.217
NRMSE	0.174	0.189	0.109	0.113	0.107
No. of Factors	3	0	5	5	5
Base MSPE	0.00246	0.00232	0.00201	0.00208	0.00209
Applied MSPE	0.00239	0.00232	0.00148	0.00159	0.00164
Treated Units	1	1	1	1	1
Control Units	19	19	19	19	19
Observations	1,360	1,360	1,360	1,360	1,360

The GSC methodology is capable of assessing both models with multiple treatment units and differential timing. The latter feature is particularly useful when assessing interventions with staggered adoption but it is debatable as to whether we can claim the significantly earlier Harlesden HSHAZ scheme fits this description. We therefore test models that incorporate all the sample HSHAZ areas, other than Harlesden, as 'full sample' models.

Some care is required here. The Xu GSC approach implies simple averaging across individual treatment units (equal weighting of ratios). Adopting an alternative, such as a weighted ratio reflecting the differential scale of footfall across areas, may result in substantially differing outcomes.

Table C11 details the 'equal weight' outcomes and indicates that all models identify four latent factors as appropriate for modeling purposes with MSPE reductions in the range of 47% to 49%. RMSE for the pre-period timeframe ranges from 0.0098 to 0.0107, a narrow range, with a slight reduction towards earlier periods. The data is consistent in that there appears to be limited impact on correspondence of pre-period actual and synthetic control ratios. More generally, pre-period NRMSEs are notably lower than all of the individual areas.

RMSEs for the post period are higher in each model implying a unit differential. Analysis of the data indicates a marginal downward drift in the synthetic control but models produce a broadly similar set of coefficient values and ATT coefficients are strongly significant for all periods.

Table C11: Full Sample HSHAZ SCM Profile (Equal Weight)

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	n/a	n/a	n/a	n/a	n/a
ATT Coefficient	0.058** (0.024)	0.052*** (0.017)	0.047*** (0.016)	0.052*** (0.019)	0.057*** (0.017)
RMSE (Pre)	0.0107	0.0107	0.0107	0.0104	0.0098
RMSE (Post)	0.0682	0.0559	0.0528	0.0577	0.0621
RMSE Ratio	5.412	5.238	4.921	5.566	6.299
NRMSE	0.039	0.039	0.039	0.038	0.036
No. of Factors	4	4	4	4	4
Base MSPE	0.00577	0.00559	0.00506	0.00491	0.00487
Applied MSPE	0.00303	0.00296	0.00260	0.00262	0.00259
Treated Units	9	9	9	9	9
Control Units	19	19	19	19	19
Observations	1,904	1,904	1,904	1,904	1,904

Urban HSHAZ Areas

Seven of the ten sample HSHAZ areas are located in more urban centres and in this section, we run models focusing on these areas alone. Table C12 indicates that all such models identify 5 latent factors as appropriate for modeling purposes with MSPE reductions in the range of 16% to 30%. It is also evident that percent reductions increase moving from earlier to later models.

RMSE for the pre-period timeframe ranges from 0.0104 to 0.0113, a narrow range not too dissimilar from the 'full sample' analysis though with no particular trend across periods, other than a minor reduction in the earliest period. Data is consistent in that there appears to be limited impact on correspondence of pre-period actual and synthetic control penetration ratios across models. As with the full sample, pre-period NRMSEs are lower than all of the individual areas.

RMSEs for the post period are higher in each model implying a unit differential with RMSE ratios mostly higher than those for the full sample. Inspection of the data indicates very limited change in the synthetic control. There is, however, more variation in coefficient values than in the full sample. ATT coefficients are strongly significant for all periods.

Table C12: Town Centre HSHAZ SCM Profile

	April 2024	January 2024	October 2023	July 2023	April 2023
Spend %	n/a	n/a	n/a	n/a	n/a
ATT Coefficient	0.081*** (0.018)	0.047*** (0.015)	0.038*** (0.010)	0.043*** (0.013)	0.052*** (0.013)
RMSE (Pre)	0.0113	0.0112	0.0112	0.0111	0.0104
RMSE (Post)	0.0813	0.0668	0.0586	0.0618	0.0645
RMSE Ratio	7.211	5.985	5.231	5.580	6.199
NRSME	0.039	0.038	0.039	0.038	0.036
No. of Factors	5	5	5	5	5
Base MSPE	0.00501	0.00484	0.00425	0.00414	0.00418
Appied MSPE	0.00345	0.00340	0.00313	0.00338	0.00351
Treated Units	7	7	7	7	7
Control Units	13	13	13	13	13
Observations	1,360	1,360	1,360	1,360	1,360

Summary

A total of 10 HSHAZ schemes are examined through the GSC SCM approach along with overall and town centre aggregates. Table C13 brings together the ATT coefficients of each. For convenience, significance is also colour coded with yellow indicating significance at 10%, orange indicating significance at 5% and green indicating significance at 1%.

Of the 10 schemes, four (Leeds, Poole, Swaffham, Wakefield) show no real sign of any positive impact The only area with persistent positive impact is Tyldesley, significant across all time points.

While three areas (Gloucester, Harlesden, Tyldesley) suggest positive impact for the most recent period tested, a number of others suggest impacts at relatively early periods with some coefficients tending to decline in scale in progression towards more recent periods (Leominster, Middlesbrough, Ryde). This is consistent with a hypothesis that some amenity benefits may be evident well before the nominal end of schemes.

Table C13: Summary ATT Profile

	April 2024	January 2024	October 2023	July 2023	April 2023
Gloucester	0.100** (0.051)	0.069* (0.041)	0.048 (0.036)	0.018 (0.040)	0.019 (0.033)
Harlesden*	0.066* (0.035)	0.077** (0.037)	0.077** (0.032)	0.006 (0.015)	-0.019* (0.011)
Leeds	-0.034 (0.066)	-0.027 (0.036)	-0.048 (0.039)	-0.049 (0.051)	-0.059 (0.045)
Leominster	0.044 (0.073)	0.058 (0.048)	0.079* (0.044)	0.112** (0.054)	0.111** (0.054)
Middlesbrough	0.118 (0.081)	0.113** (0.053)	0.094** (0.039)	0.136** (0.065)	0.146*** (0.052)
Poole	0.076 (0.058)	0.082 (0.055)	0.003 (0.053)	0.031 (0.029)	0.031 (0.029)
Ryde	0.085 (0.094)	0.093* (0.055)	0.116* (0.066)	0.168*** (0.051)	0.151*** (0.048)
Swaffham	0.058 (0.070)	0.043 (0.054)	0.029 (0.049)	0.013 (0.056)	0.078 (0.054)
Tyldesley	0.155** (0.069)	0.076** (0.036)	0.080** (0.035)	0.097** (0.038)	0.094** (0.037)
Wakefield	0.000 (0.059)	-0.051 (0.055)	-0.061* (0.035)	-0.037 (0.038)	-0.039 (0.036)
Combined Sample	0.058** (0.024)	0.052*** (0.017)	0.047*** (0.016)	0.052*** (0.019)	0.057*** (0.017)
Town Centre Sample	0.081*** (0.018)	0.047*** (0.015)	0.038*** (0.010)	0.043*** (0.013)	0.052*** (0.013)

Although there is a clear lack of covariate datasets, we have tested each of the models in Table C13 including a broad estimate of sunshine hours for the wider geographies in which the HSHAZ schemes are located (as an attempt to control for differential weather conditions). In practice, the coefficients barely alter.

If we are willing to assume that significant positive coefficients represent responses to HSHAZ intervention, with no notable bias due to omitted variables, the modelling outcomes suggest something of mixed fortunes across sample areas. In such circumstances, we can also attempt to establish a broad 'impact' effect. Such assumptions are easily challenged but the exercise provides a simple scalar for scrutiny and discussion.

In undertaking this analysis, we are required to make assumptions about the persistence of any implied impact. As we deal with different time periods, we adopt a strategy of assuming all impacts persist until August 2024, regardless of assessment point[8]. Table C14 reports the outcomes of this process at a daily footfall equivalent.

With the exception of the April 2024 period for Tyldesley, and the sole Gloucester impact for January 2024, 'impact' profiles for areas with a run of significant coefficients profile as follows:

- Harlesden: 3,000 (October 2022/January 2023 only)
- Leominster: 2,500/2,900 (April 2023/July 2023 only)
- Middlesbrough: 2,600/3,900 (April 2023/January 2024)
- Ryde: 2,500/3,200 (April 2023/July2023 only)
- Tyldesley 1,600/1,900 (April 2023/January 2024)
- Full Sample: 5,700/7,000 (April 2023/April 2024)
- Town Centre Sample: 3,600/6,200 (April 2023/April 2024)

[8] Different strategies will result in differing scalars.

Table C14: ATT Impact Profiles (Daily Impact)

	April 2024	January 2024	October 2023	July 2023	April 2023
Gloucester	739				
Harlesden*		3,036	3,033		
Leeds					
Leominster				2,943	2,532
Middlesbrough		3,938	2,661	3,284	3,189
Poole					
Ryde				3,171	2,577
Swaffham					
Tyldesley	4,698	1,687	1,650	1,957	1,818
Wakefield					
Combined sample	5,783	6,067	5,721	6,434	6,977
Town Centre Sample	6,220	4,259	3,616	4,156	4,954